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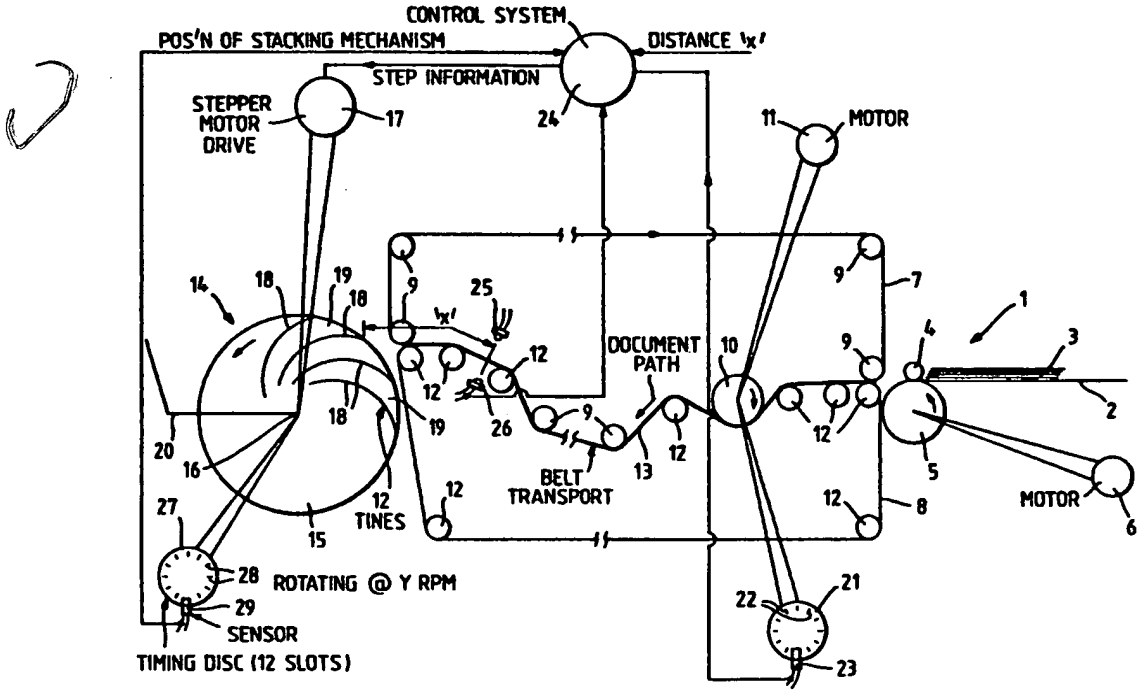
(54) Sheet feeding

(57) A method of feeding sheets, such as bank notes, from an input station (1) of sheet feeding apparatus along a feed path (13) to a stacking mechanism (14) is described. Sheets are fed singly from a stack (3) along the feed path (13). A first sensor (25, 26) senses for the presence of sheets at a predetermined distance (X) along the feed path (13) from the stacking mechanism (14). A second sensor (21, 23) senses the feed speed of the sheets. A microprocessor (24) then synchronises the stacking mechanism (14) with the flow of sheets along the feed path (13) in response to output signals from the first and second sensors (25, 26; 21, 23).



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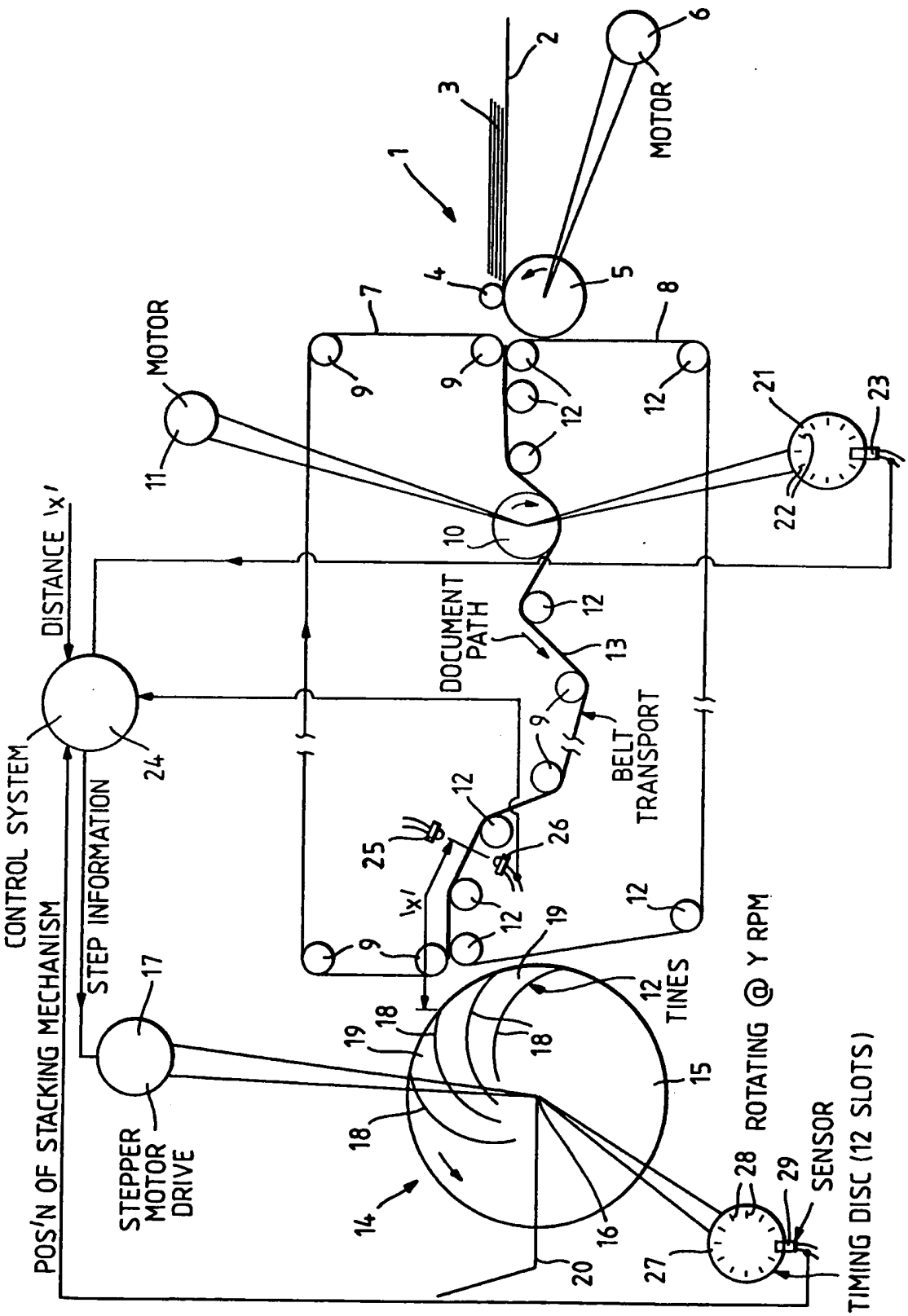
The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.


MOTOR
MOTOR
DISTANCE 'x'
CONTROL SYSTEM
POS'N OF STACKING MECHANISM
STEP INFORMATION
STEPPER MOTOR DRIVE
DOCUMENT PATH
BELT TRANSPORT
TINES
ROTATING @ Y RPM
SENSOR
TIMING DISC (12 SLOTS)

SPECIFICATION

Sheet feeding

The invention relates to sheet feeding apparatus and a method of feeding sheets from an input station along a feed path to a stacking mechanism. In particular, the invention relates to the feeding of security documents such as bank notes, cheques or bonds and the like.

In conventional sheet feeding apparatus a stack of sheets is placed at an input station and a feed mechanism passes sheets singly along the feed path to the stacking mechanism. As the sheets pass along the feed path various tests and other procedures are carried out. For example, the sheets may simply be counted to determine the number of sheets in the stack. Additionally, or alternatively, the sheets may be tested for authenticity or that they are otherwise fit (i.e., not folded or torn). In these latter cases, unfit sheets or forged sheets may be diverted to one stacking mechanism while fit sheets are passed to another stacking mechanism.

One of the problems which has arisen is that when the feed path is long a certain amount of slippage occurs while the sheets are fed along the feed path. In addition the apparatus involves a large number of separate moving parts. This means that when the sheets reach the stacking mechanism they are not synchronised with the stacking mechanism so that misfeeds to the stacking mechanism can occur. These misfeeds may require that the apparatus is temporarily stopped to allow the badly fed notes to be extracted manually which is clearly time consuming and undesirable. These problems are particularly apparent at the high feed speeds which are now being used.

In accordance with one aspect of the present invention, a method of feeding sheets from an input station along a feed path to a stacking mechanism comprises feeding the sheets singly from the input station along the feed path; sensing for the presence of sheets at a predetermined distance along the feed path from the stacking mechanism; monitoring the feed speed of the sheets; and thereby synchronising the stacking mechanism with the flow of sheets along the feed path.

In theory, synchronisation between the stacking mechanism and the flow of sheets could be obtained by controlling the feed timing, controlling the stacking mechanism or both. However, we have discovered that controlling the stacking mechanism leads to the most advantageous arrangement since attempts at controlling the feed timing will be much more difficult since a complex transport mechanism, which may be in several portions, will need to be controlled.

Preferably, the method further comprises monitoring the position of the stacking mechanism. This assists synchronisation when the position of the stacking mechanism cannot be inferred from other sources.

Conveniently, the monitoring step comprises monitoring the speed of a transport mechanism defining the feed path. This provides a particular simple way to monitor the sheet speed avoiding the necessity of sensing the passage of the sheets directly. For example, where the feed path is defined by conveyor belts, the sheet speed will be equal to the speed of the conveyor belt which could be sensed by monitoring the rotation speed of a conveyor belt drive wheel.

Typically, the stacking mechanism will comprise a plurality of sheet receiving slots rotatable about an axis, each slot being adapted to receive a single sheet from the feed path, and a stepping motor for controlling rotation of the sheet receiving slots. With this mechanism, synchronisation of the stacking mechanism with the flow of sheets may be obtained by adjusting the stepping rate of the stepping motor.

In accordance with a second aspect of the present invention, sheet feeding apparatus comprises an input station; a stacking mechanism; and a feed path mechanism for feeding sheets singly from the input station to the stacking mechanism, and is characterised in that the apparatus further comprises a first sensor for sensing the presence of sheets at a predetermined distance along the feed path from the stacking mechanism; a second sensor for sensing the feed speed of the sheets; and control means for synchronising the stacking mechanism with the flow of sheets along the feed path in response to output signals from the first and second sensors.

The control means may be provided by a microprocessor.

When the feed path mechanism comprises one or more conveyor belts and a drive wheel causing movement of the conveyor belts, the second sensor may comprise a timing disc rotable with the drive wheel and associated sensing means for monitoring rotation of the timing disc. For example, the timing disc could be slotted and the sensing means comprise a phototransistor and a light emitting diode arranged on opposite sides of the timing disc, output signals from the phototransistor being fed to the control means.

The first sensor may be provided by a light emitting diode and a photodetector arranged on opposite sides of the feed path for detecting a leading edge of the sheet.

Preferably, the stacking mechanism comprises a plurality of sheet receiving slots rotatable about an axis, each slot being adapted to receive a single sheet from the feed path, and a stepping motor for controlling rotation of the sheet receiving slots, the control means controlling the stepping rate of the stepping motor to obtain synchronisation.

With this stacking mechanism, single sheets are received by each slot and carried around the axis to a stacking position where they are released from the slots on to the stack.

The slots may be defined by grippers but preferably the stacking mechanism comprises one or more stacking wheels having a plurality of tines defining the sheet receiving slots, the stacking wheel or wheels co-operating with a stacking plate whereby sheets between the tines are stripped from the stacking wheel by the stacking plate.

Typically, two stacking wheels will be provided spaced apart along the axis by a distance less than the width of a sheet.

In some situations, particularly at start-up, it is desirable for the control means to determine the position of the stacking mechanism relatively to the sheets in the feed path. Conveniently therefore the apparatus further comprises a third sensor for sensing the position of the stacking mechanism and for providing a corresponding output signal to the control means.

Where the stacking mechanism comprises a plurality of sheet receiving slots rotatable about an axis (as described above) the third sensor may comprise a timing disc rotatable with the stacking mechanism and associated sensing means for providing an output signal to the control means related to the rotational position of the stacking mechanism.

The sheet feeding apparatus may be used in a variety of applications. For example, the apparatus could be used as sheet counting apparatus with either a separate sensor for sensing the sheets or by utilising output signals from the first sensor, these output signals being fed to the control means which will increment a counter accordingly. Alternatively, or additionally, the feed path may carry the sheets past authentication detectors and/or other detection means of a conventional form.

The invention has a number of advantages:

1. Sheets can be correctly stacked even though they may have random arrival times at the stacking mechanism.

2. No mechanical means is required to link the stacking mechanism to the feed path mechanism.

3. Modular systems may be configured without the need to synchronise one module to the next or to any feed path mechanism.

4. The degree of precision normally required for feeding sheets is reduced.

An example of banknote feeding apparatus and a method of feeding bank notes according to the invention will now be described with reference to the accompanying diagrammatic drawing.

The apparatus comprises an input station 1 having a support plate 2 on to which a stack of bank notes 3 is laid. The bank notes are fed from the bottom of the stack 3 in a conventional manner into a nip between a pair of rollers 4, 5. The roller 5 is driven in an anti-clockwise direction by a motor 6. The rollers 4, 5 feed the bank notes into a feed path defined by a pair of conveyor belts 7, 8. The conveyor belt 7 is entrained around a number of idler rollers 9 (only some of which are shown) and a drive wheel 10. The drive wheel 10 is driven in a clockwise direction by a motor 11.

The conveyor belt 8 is entrained around idler rollers 12 (only some of which are shown in the drawing).

Rotation of the drive wheel 10 causes movement of the conveyor belts 7, 8 with the bank notes sandwiched between them. The conveyor belts 7, 8 define a feed path 13 leading from the input station 1 to a stacking mechanism 14.

The stacking mechanism 14 comprises a pair of stacking wheels 15, only one of which is shown, rotatably mounted to a common axle 16. The stacking wheels 15 are spaced apart by a distance less than the width of the bank notes being fed. The stacking wheels 15 are driven in a stepwise manner in an anti-clockwise direction by a stepping motor 17. Each stacking wheel 15 has twelve tines 18 (four of which are shown in the drawing). Banknote receiving slots 19 are defined between each pair of tines 18.

As each bank note reaches the end of the feed path 13 it enters a sheet receiving slot 19 and is carried by rotation of the stacking wheels 15 in an anti-clockwise direction. A stacking plate 20 has a horizontal portion extending between the stacking wheels 15 which engages radially inner ends of the sheets and strips the sheets from the slots 19 so that they stack against an inclined portion of the plate 20.

A portion of the feed path 13 is not shown but may pass through conventional detecting apparatus for detecting the authenticity of the bank notes. In addition, or alternatively, the feed path may pass through conventional doubles detect apparatus for detecting the passage of two or more notes simultaneously, the detecting apparatus being associated with suitable diverters. Such double detect apparatus may be similar to that shown in our European patent specification no. 0080309.

A timing disc 21 having a number of slots 22 is mounted non-rotatably to the drive wheel 10. This is indicated diagrammatically in the drawing. A sensor 23 is provided for sensing rotation of the timing disc 21. The sensor 23 comprises a light emitting diode (LED) positioned on one side of the timing disc 21 and a phototransistor mounted on the other side in alignment with the LED. As the timing disc 21 rotates, light from the LED will periodically pass through slots 22 and impinge on the phototransistor. This will then output an appropriate signal to a microprocessor 24. The rate at which output signals are generated

by the phototransistor of the sensor 23 provides a parameter from which the microprocessor 24 can calculate the speed with which sheets are fed along the feed path 13.

At a predetermined distance "X" along the feed path from the tipof the nearest tine of the stacking mechanism 14 are positioned an LED 25 and phototransistor 26 on opposite sides of the feed path 13. Normally, light will be received by the phototransistor 26 but the light will be cut off as soon as a leading edge of a sheet reaches this position. This cut off is signalled to the microprocessor 24 so that the position of the sheet is accurately determined. The value of X depends on a variety of variables. In one example X is about 250 mm. A typical note will have a length less than 200 mm.

Another timing disc 27 having twelve slots 28 is mounted non-rotatably to the axle 16. A sensor 29 similar to the sensor 23 is mounted in such a position that correspondence can be determined between the relative positions of the slots 28 and sensor 29 and the sheet receiving slots 19. The sensor 29 provides an output to the microprocessor 24.

In use, the microprocessor 24 continuously receives signals from the sensor 23 from which it can determine the speed with which sheets are fed along the feed path 13. As soon as a bank note interrupts the passage of light between the LED 25 and the phototransistor 26 the microprocessor 24 senses that a sheet has reached the predetermined distance X from the stacking mechanism 14. The position of the stacking mechanism 14, as determined by the timing disc 27 and sensor 29 is monitored by the microprocessor 24. Since the microprocessor 24 knows the feed speed of the bank notes and the distance X it can calculate a time for the bank note to reach the stacking mechanism 14. In addition, it can determine whether there will be a sheet receiving slot 19 correctly positioned to receive the sheet. The microprocessor 24 also knows the stepping rate of the stepping motor 17. From this information, it can determine whether an adjustment in the stepping rate of the stepping motor 17 is necessary in order to bring a sheet receiving slot 19 into the correct position.

Once the sheet receiving slot 19 is in the correct position, the microprocessor 24 causes the stepping motor 17 to return to its original, nominal stepping rate.

This process can then repeated for every bank note if necessary.

Typically, bank notes will be fed from the stack 3 at a rate of 15 notes per second while the feed speed will be about 4m per second.

CLAIMS

1. A method of feeding sheets from an input station along a feed path to a stacking mechanism, the method comprising feeding the sheets singly from the input station along the feed path; sensing for the presence of sheets at a predetermined distance along the feed path from the stacking mechanism; monitoring the feed speed of the sheets; and thereby synchronising the stacking mechanism with the flow of sheets along the feed path.

2. A method according to claim 1, wherein the monitoring step comprises monitoring the speed of a transport mechanism defining the feed path.

3. A method according to claim 1 or claim 2, wherein the stacking mechanism comprises a plurality of sheet receiving slots rotatable about an axis, each slot being adapted to receive a single sheet from the feed path, and a stepping motor for controlling rotation of the sheet receiving slots, synchronisation of the stacking mechanism with the flow of sheets being obtained by adjusting the stepping rate of the stepping motor.

4. A method of feeding sheets from an input station along a feed path to a stacking mechanism substantially as hereinbefore described with reference to the accompanying drawing.

5. Sheet feeding apparatus comprising an input station; a stacking mechanism; and a feed path mechanism for feeding sheets singly from the input station to the stacking mechanism, characterised in that the apparatus further comprises a first sensor for sensing the presence of sheets at a predetermined distance along the feed path from the stacking mechanism; a second sensor for sensing the feed speed of the sheets; and control means for synchronising the stacking mechanism with the flow of sheets along the feed path in response to output signals from the first and second sensors.

6. Apparatus according to claim 5, wherein the stacking mechanism comprises a plurality of sheet receiving slots rotatable about an axis, each slot being adapted to receive a single sheet from the feed path, and a stepping motor for controlling rotation of the sheet receiving slots, the control means controlling the stepping rate of the stepping motor to obtain synchronisation.

7. Apparatus according to claim 6, wherein the stacking mechanism comprises one or more stacking wheels having a plurality of tines defining the sheet receiving slots, the stacking wheel or wheels co-operating with a stacking plate whereby sheets between the tines are stripped from the stacking wheel by the stacking plate.

8. Apparatus according to any one of claims 5 to 7, further comprising a third sensor for sensing the position of the stacking mechanism and for providing a corresponding output signal to the control means.

9. Sheet feeding apparatus substantially as hereinbefore described with reference to the

accompanying drawing.

10. Banknote feeding apparatus according to any of claims 5 to 9.

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